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OPTIMIZING CUCUMBER GROWTH AND NITROGEN EFFICIENCY THROUGH ROOTSTOCKS AND FERTIGATION UNDER POLYHOUSE

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ABSTRACT

Cucumber (*Cucumis sativus* L.), a prominent vegetable in protected farming systems, is valued for its high nutritional content. This study, conducted over two years (2022 and 2023) at Grafting unit, Department of Vegetable Science, CCS Haryana Agricultural University, examined the impact of different rootstocks and fertigation levels on cucumber performance. Using a randomized block design, the research involved sixteen treatments combining various rootstocks (Pumpkin, Bottle gourd, Sponge gourd, and non-grafted) with different fertigation levels (80% RDF, 100% RDF, 120% RDF, and 140% RDF). Key parameters measured included vine length, number of nodes per plant, and nitrogen use efficiency (NUE). Results indicated significant differences in vine length at both 40 and 70 days after transplanting, with Bottle gourd (R2) showing the greatest growth compared to other rootstocks. Among fertigation levels, 140% RDF (F4) resulted in the longest vines, while 80% RDF (F1) optimized NUE. Interaction effects were notable for the number of nodes, with the best results occurring when Bottle gourd was paired with higher fertigation levels. The study highlights the benefits of using Bottle gourd rootstock and adjusting fertigation levels to enhance cucumber growth and nutrient efficiency. These findings offer valuable insights for optimizing cucumber cultivation in protected environments, aiming to improve both yield and resource utilization.

Key words : Fertigation, Grafting, Nutrient use efficiency**,** Rootstock, Vine length

Introduction

Cucumber (*Cucumis sativus* L., 2n=14), the most lucrative vegetable crop cultivated worldwide under protected farming systems, belongs to the family Cucurbitaceae (El-Wanis *et al*., 2012). Cucumber has high nutritional value and contains calcium, magnesium, potassium, dietary fiber, and all eight macronutrients (Hashem *et al*., 2011). In India, due to its expansive size and varied agro-climatic conditions, the technology of protected vegetable cultivation can be harnessed for the continuous production of premium quality vegetable crops with a high yield. Protected cultivation enables the attainment of high water and nutrient use efficiencies. Along with this, Grafting is a useful method for preventing soil-borne diseases, providing resistance to biotic and abiotic stress, improving nutrient uptake, maximizing water use efficiency, and raising fruit output and quality. Vegetable seedlings with grafts are used to increase crop vigour and productivity in several nations nowadays. The robust root system of the rootstock improves the efficiency of water and nutrient uptake and may also act as a source of endogenous plant hormones, resulting in greater growth and yield as well as disease prevention.

Fertilizer is a major part of the crop expenses for cucumber production and it is critical for successful crop yields and high fruit quality. Fertilizer requirements of cucumber are quite high due to its high yielding potential per unit area and time. The correct quantity of fertilizer application through proper practices not only increases the yield but also improves the quality. Studies have demonstrated that optimizing fertigation strategies can lead to increased yields, improved nutrient use efficiency, and enhanced nutrient uptake by cucumber plants. For example, nutrient-based fertigation scheduling has been

found to maximize cucumber yield and water use efficiency (Randhe *et al*., 2022). Moreover, grafting onto suitable rootstocks can help combat biotic stresses and abiotic stresses, increasing nutrient use efficiency, ultimately enhancing cucumber quality and yield under normal and stressful conditions.

Materials and Methods

This study was conducted over two years at the Grafting Unit of the Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar (located at 29°09'N latitude and 75°43'E longitude, with an elevation of 215 meters). The research took place during Aug- Sept season of 2022-23 and 2023-24. The cucumber scion (Pusa Parthenocarpic Cucumber-6) was grafted onto various rootstocks, and fertigation was applied during its cultivation under polyhouse conditions. The experiment was laid out in randomized block design (RBD) consisting of sixteen treatments with three replications. The treatments were comprised of: T1- Rootstock Pumpkin (R1) + 80% RDF (F1); T2- Rootstock Pumpkin (R1) + 100% RDF (F2); T3- Rootstock Pumpkin (R1) + 120% RDF (F3); T4- Rootstock Pumpkin (R1) + 140% RDF (F4); T5- Rootstock Bottle gourd (R2) + 80% RDF (F1);T6- Rootstock Bottle gourd (R2) + 100% RDF (F2); T7- Rootstock Bottle gourd (R2) + 120% RDF (F3); T8- Rootstock Bottle gourd (R2) + 140% RDF (F4); T9- Rootstock Sponge gourd (R3) + 80% RDF (F1);T10- Rootstock Sponge gourd (R3) + 100% RDF (F2); T11- Rootstock Sponge gourd (R3) + 120% RDF (F3); T12- Rootstock Sponge gourd (R3) + 140% RDF (F4); T13- Non-graft/Control (R0) + 80% RDF (F1); T14- Non-graft/Control (R0) + 100% RDF (F2); T15- Non-graft/ Control (R0) + 120% RDF (F3); T16- Non-graft/Control (R0) + 140% RDF (F4). Recommended dose of fertilizers (RDF) considered was NPK 50:25:25 (kg/ha). Following successful grafting and the healing process, the seedlings were transplanted onto beds within the polyhouse in September of both 2022 and 2023. The recorded parameters were: Vine length at 40 and 70 DAT, number of nodes per plant, and nitrogen use efficiency. Statistical analysis of experimental data was conducted using the OPSTAT software package.

Results and Discussion

The data on vine length (cm) of cucumber at 40 days after transplanting (DAT) is presented in Table 1. The

Table 1: Effect of different rootstocks and fertigation levels on vine length of cucumber at 40 DAT under polyhouse.

	2022-23					2023-24					Pooled				
	F1	**F2**	**F3**	**F4**	**Mean**	**F1**	**F2**	**F3**	**F4**	**Mean**	**F1**	**F2**	**F3**	**F4**	**Mean**
R1	67.90	72.60	78.10	81.20	74.95	71.15	77.30	80.10	83.93	78.12	69.52	74.95	79.10	82.56	76.53
R2	69.20	73.50	79.20	84.50	76.60	73.26	81.10	83.00	88.16	81.38	71.23	77.30	81.10	86.33	78.99
R3	61.20	64.20	68.00	70.15	65.89	64.10	68.50	68.90	73.14	68.66	62.65	66.35	68.45	71.64	67.28
R0	62.30	66.70	70.20	72.10	67.83	63.82	69.20	71.20	71.90	69.03	63.06	67.95	70.70	72.00	68.43
Mean	65.15	69.25	73.88	76.99		68.08	74.03	75.80	79.28		66.62	71.64	74.84	78.13	
CD @ 5%															
R	5.66					4.99					5.21				
F	5.66					4.99					5.21				
R × F	NS					NS					NS				

Table 2. Effect of different rootstocks and fertigation levels on vine length of cucumber at 70 DAT under polyhouse.

	2022-23					2023-24					Pooled				
	F1	**F2**	**F3**	**F4**	**Mean**	**F1**	**F2**	**F3**	**F4**	**Mean**	**F1**	**F2**	**F3**	**F4**	**Mean**
R1	107.6	111.7	113.8	115.6	112.2	110.6	115.3	116.7	117.5	115.0	109.1	113.5	115.3	116.6	113.6
R2	109.8	113.3	115.4	116.8	113.8	114.0	115.8	117.2	118.3	116.3	111.9	114.5	116.3	117.6	115.0
R3	103.9	105.6	106.6	107.1	105.8	105.3	107.2	108.0	109.5	107.5	104.6	106.4	107.3	108.3	106.6
R0	106.6	109.0	111.9	113.5	110.2	110.5	112.7	113.7	114.4	112.8	108.5	110.9	112.8	113.9	111.5
Mean	106.9	109.9	111.9	113.2		110.1	112.7	113.9	114.9		108.5	111.3	112.9	114.1	
CD @ 5%															
R	1.4					1.9					1.3				
F	1.4					1.9					1.3				
R × F	NS					NS					NS				

pooled mean vine length at 40 DAT over the two years (2022 and 2023) showed significant variation for both rootstocks and fertigation levels. Among different rootstocks, the highest vine length was recorded in R2 (Bottle gourd) (78.99 cm), which was at par with R1 (Pumpkin). The minimum vine length was recorded under R3 (Sponge gourd) (67.28 cm). This suggests that the choice of rootstock plays a critical role in the early growth stages of cucumber plants. Similarly, among different fertigation levels, the highest vine length was recorded in F4 (140% RDF) (778.13 cm) which was at par with F3 (120% RDF). The lowest vine length was recorded under F1 (80% RDF) (66.62 cm). The significant differences in vine length across fertigation levels indicate that nutrient availability directly influences vegetative growth in cucumbers. The interaction effects between rootstocks and fertilizer levels were non-significant across both seasons and in the pooled data.

The pooled mean vine length at 70 DAT (Table 2) over the two years (2022 and 2023) showed significant variation for both rootstocks and fertigation levels. Among different rootstocks, the highest vine length was recorded in R2 (Bottle gourd) (115.0 cm), followed by R1 (Pumpkin). This further reinforces the notion that Bottle gourd rootstock enhances growth performance in cucumbers. Similarly, among different fertigation levels, the highest vine length was recorded in F4 (140% RDF) (114.1 cm), which was at par with F3 (120% RDF) (112.9 cm). The lowest vine length was recorded under F1 (80% RDF) (108.5 cm). The consistent performance of the highest fertigation level across both growth stages indicates a robust relationship between nutrient supply and plant growth. The interaction effects between rootstocks and fertilizer levels were non-significant across both seasons, suggesting that while both factors independently affect vine length, their combined effects do not produce a synergistic outcome.

As far as number of nodes per vine in cucumber is concerned, the results show notable interaction effects between rootstocks and fertigation levels.In the pooled

Table 3: Effect of different rootstocks and fertigation levels on number of nodes per vine of cucumber under polyhouse.

	2022-23					2023-24					Pooled				
	F1	**F2**	**F3**	**F4**	**Mean**	**F1**	**F2**	**F3**	**F4**	**Mean**	**F1**	**F2**	**F3**	**F4**	**Mean**
R1	23.10	24.18	28.10	31.40	26.70	23.50	24.99	29.10	32.90	27.62	23.30	24.58	28.60	32.15	27.16
R2	23.90	26.20	30.90	31.80	28.20	23.50	28.87	31.00	33.10	29.12	23.70	27.53	30.95	32.45	28.66
R3	19.80	20.81	25.50	25.70	22.95	20.20	22.56	25.90	26.10	23.69	20.00	21.68	25.70	25.90	23.32
R0	23.50	23.98	27.20	27.70	25.60	24.00	24.70	27.10	28.00	25.95	23.75	24.34	27.15	27.85	25.77
Mean	22.57	23.79	27.93	29.15		22.80	25.28	28.28	30.03		22.69	24.54	28.10	29.59	
CD @ 5%															
R	2.04					2.09					2.06				
F	2.04					2.09					2.06				
R × F	NS					NS					NS				

Table 4: Effect of different rootstocks and fertigation levels on nitrogen use efficiency (q/kg N) of cucumber under polyhouse.

	2022-23					2023-24					Pooled				
	F1	**F2**	**F3**	**F4**	**Mean**	**F1**	**F2**	**F3**	**F4**	**Mean**	**F1**	**F2**	**F3**	**F4**	**Mean**
R1	11.49	10.58	9.97	8.70	10.19	11.82	10.90	10.35	8.95	10.51	11.66	10.74	10.16	8.83	10.35
R2	12.15	11.39	10.78	9.36	10.92	12.43	11.50	10.80	9.43	11.04	12.29	11.44	10.79	9.39	10.98
R3	8.98	7.62	6.99	6.05	7.41	9.43	7.85	7.14	6.24	7.67	9.20	7.74	7.07	6.15	7.54
R0	10.89	9.68	8.48	7.45	9.12	11.06	9.73	8.66	7.56	9.26	10.98	9.71	8.57	7.51	9.19
Mean	10.88	9.82	9.06	7.89		11.19	10.00	9.24	8.04		11.03	9.91	9.15	7.97	
CD @ 5%															
R	0.22					0.23					0.17				
F	0.22					0.23					0.17				
R × F	0.43					NS					0.35				

R1- Pumpkin, R2- Bottle gourd, R3- Sponge gourd, R0- Control/ Non-grafted
F1 – 80% RDF, F2- 100% RDF, F3- 120% RDF, F4- 140% RDF
(RDF= Recommended dose of fertilizers @50:25:25 NPK (kg/ha); NS- Non-Significant)

data over both years (Table 3), R2 (Bottle gourd) had the highest number of nodes (28.66 nodes), which was statistically found at par with R1 (Pumpkin) (27.16 nodes) and significantly higher than R3 (Sponge gourd) (23.32 nodes). The increased number of nodes in R2 and R1 suggests that these rootstocks may possess superior physiological traits that promote branching and node development, which are essential for maximizing fruiting potential and overall yield. Among fertigation levels, F4 (140% RDF) resulted in the highest number of nodes (29.59 nodes), followed by F3 (120% RDF) (28.10 nodes). The lowest number of nodes was recorded under F1 (80% RDF) (22.69 nodes). The effect of interaction between rootstocks and fertigation levels was found non-significant for the number of nodes per vine in cucumber. The non-significant interaction effect suggests that while both rootstock and fertigation levels independently influence node development, their combined effect does not lead to a statistically significant enhancement in node numbers. Research has shown that rootstocks with superior nutrient uptake characteristics can significantly improve the overall performance of grafted plants (Uysal *et al.*, 2012).

Table 4 summarizes the Nutrient Use Efficiency (NUE) where the pooled mean data reveal that R2 (Bottle gourd) consistently had the highest NUE (10.98 q/kg N), while R3 (Sponge gourd) had the lowest (7.54 q/kg N). Among the fertigation levels, F1 (80% RDF) achieved the highest NUE (11.03 q/kg N), while F4 (140% RDF) had the lowest (7.97 q/kg N). The interaction effects between rootstocks and fertigation levels were significant over the pooled seasons where it was found that the rootstockR2 (Bottle gourd) supplied with F1 (80% RDF) exhibited highest NUE (12.29 q/kg N), followed by R1 supplied with F1. This might be due to the precise application of fertilizers to the restricted volume of soil where the active roots were concentrated and hence was available to plants fully. Deolankar and Firake (1999) also reported the maximum fertilizer use efficiency with 75% recommended NPK in chilli.

Conclusion

Based on a two-year study, it is advised to use Bottle gourd (R2) as the rootstock for grafting cucumbers and to apply 140% RDF (F4) fertigation to achieve optimal vine growth and yield. For enhanced nutrient use efficiency, pairing Bottle gourd with 80% RDF (F1) is recommended. Implementing these practices will improve both crop performance and fertilizer efficiency.

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